

## A description of the remarkable larva of *Pseudolestes mirabilis* Kirby (Odonata: Pseudolestidae)

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The larva of the Chinese endemic *Pseudolestes mirabilis* is described and figured for the first time. Specimens were collected from Hainan, the only known locality for this species. The presence of ventral paired gill tufts on S10 and sack-like caudal gills indicate that among other zygopteran families this species may be most closely related to the Amphipterygidae, but other characters, especially those of the adult suggest it may be sufficiently unique to warrant placement in its own family.

**Keywords:** Odonata; dragonfly; Zygoptera; Pseudolestidae; *Pseudolestes mirabilis*; larva

### Introduction

*Pseudolestes mirabilis*, the well-known Chinese endemic species, has been the subject of considerable recent speculation with regard to its phylogenetic position. Based on its unusual and unique adult characters the species was originally placed in its own subfamily by Kirby (1900). Calvert (1902) and Tillyard and Fraser (1938–1940) placed it in subfamily Lestinae (now Lestidae). Fraser (1957) then established the family Pseudolestidae to house *Pseudolestes* and several other genera, which was followed by Davies and Tobin (1984) and van Tol (2006). However recent phylogenetic studies using molecular techniques (Bybee, Ogden, Branham & Whiting, 2008) suggest this species belongs in the Megapodagrionidae. The larvae of megapodagrionids have been divided into four groups by Kalkman, Choong, Orr and Schütte (2010): (1) species with inflated sack-like gills with a terminal filament; (2) species with flat vertical gills; (3) species in which the outer gills in life form a tube folded around the median gill; (4) species with flat horizontal gills. Kalkman et al. (2010) discussed the likely characters of unknown larvae of supposed megapodagrionids (including *P. mirabilis*) and suggested that the larva of *P. mirabilis* would fall into above group 1, i.e. having sack-like gills. This study provides a detailed description of the larva of *P. mirabilis* and discusses the phylogenetic implications of its unusual characters.

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## Area and methods

Larvae were found in both shady and open montane streams with shallow water and stony substrates in Diaoluoshan and Baiwangling, Hainan, China. Adults were present around the site and at nearby streams in moderate numbers. Larvae were collected using a dip net with removal of big stones by hand. Though vegetation of the surrounding area was also searched thoroughly to a height of 2 m, exuviae were only found on stones extending above the stream surface. Attempts were made to rear collected larvae in the laboratory in plastic containers but failed. Living photos were taken in the field before or just after collecting with a digital camera (Canon Power Shot A710). Character photos were taken in the laboratory using Diagnostic Spot CCD camera adapted to the stereo microscope Nikon SMZ1000. Specimens except the exuviae were preserved in absolute ethanol and were examined and dissected under a stereo microscope Olympus C011. The dorsal habitus photograph (Figure 1a) was supplied by Haomiao Zhang.

## Description of Larvae

### *Pseudolestes mirabilis* (Figures 1–3)

#### *Material examined*

1♂ exuviae, Diaoluoshan, Hainan, China, 1 June 2007, Xin Yu leg.; 1♀, Baishuiling, Diaoluoshan, Hainan, China, 29 May 2007, Ji-Meng Hua leg.; 1♂, Bawangling, Hainan, China, 9 June 2007, Ji-Meng Hua leg.

#### *Diagnosis*

A robust zygopteran with a large head, short legs and sack-like gills. A tuft of abdominal gills is present ventrally on the final segment (Figure 1a). Ground colour of body dark brown, lacking distinct bands or marks.

#### *Description*

**Head.** Relatively broad, exceeding maximum breadth of mesothorax; in dorsal view general shape a compressed pentagon, with the posterior side deeply excavated to form a rounded margin. Postocular lobes somewhat swollen. Antennae 7-segmented, moderately long and evenly tapered, segments of equal length except the apical one, which is just half the length of others and inconspicuous. Labium (Figure 2a) elongate; prementum about 1.7 times as long as broad and basally narrow. Distal lobe moderately convex with strong marginal crenulations; median cleft short. Labial palp (Figure 2a, b) robust, lacking setae; distally with two strong, short, incurved teeth and small short securiform process on the inner margin just basad of inner tooth; movable hook long and robust. Maxilla (Figure 2g–j) twice as long as broad. Galea and lacinia partly fused; lacinia terminating in four long sharp spines, forming a curved, inward-directed, pitchfork-like structure; galea with three shorter spines directed upward. Palp with short basal segment and a single long banana-shaped terminal segment, reaching to base of most distal spines on galeo-lacinia, covered in dense long setae for the distal two-thirds of its length. Right mandible (Figure 2c–d) with four well developed incisors and a fifth innermost tooth; outermost (ventral) tooth with small secondary tooth well before its apex; molar crest produced to form a well-defined curved bifid spine (thus, in the terminology of M.C. Watson [1956], R 12344' y ab). Left mandible (Figure 2e–f) with similar

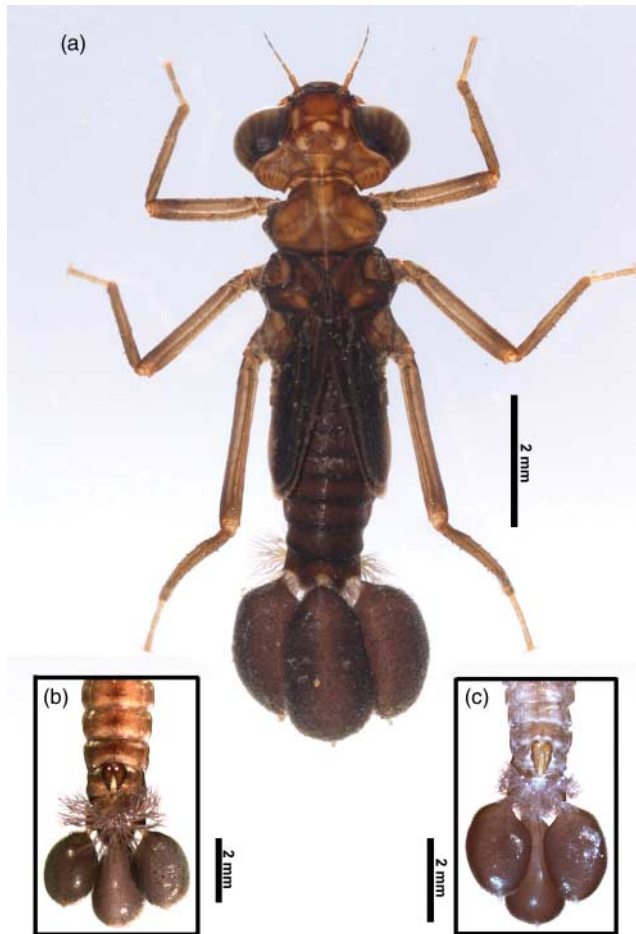


Figure 1. (a) Larval habitus of *Pseudolestes mirabilis*, final stadium female, photo by Haomiao Zhang; (b) final stadium male, ventral view of end of abdomen showing gill tufts; (c) F-1 stadium female, ventral view of end of abdomen showing gill tufts.

incisors; molar crest produced straight, with distal edge serrated with seven fine cusps (L 12344' y a(m<sup>1,2,3,4,5</sup>)b).

**Thorax.** Prothorax robust; anterior one quarter rather narrow but posterior to this strongly expanded laterally with paired, solid, blunt processes around the midpoint of the margin. Meso- and metathorax irregular, rounded, sub-rectangular in shape. Legs moderately short and strong, bearing scattered short spines and hairs, lacking bands or other marks; legs progressively slightly longer from pro- to metathorax. Wing pads moderately long, flat and narrow, almost reaching to distal margin of S7 in specimen with relatively contracted abdomen (Figure 1a).

**Abdomen.** Robust and elongate with paired, possibly retractable, gill tufts on the venter of S10. Gonapophyses well developed in male, projecting from anterior margin of S9 to almost the end of this segment (Figure 1b). In female outer gonapophyses projecting from anterior margin of S9 to middle of S10; inner gonapophyses reaching still further (Figure 1c). Cerci wholly concealed by expanded gill tufts in ventral view (Figure 1a,b). Inflated sack-like caudal gills covered in short, stout setae; football-like in the final larva (Figure 1) with blunt apical projections, slightly longer

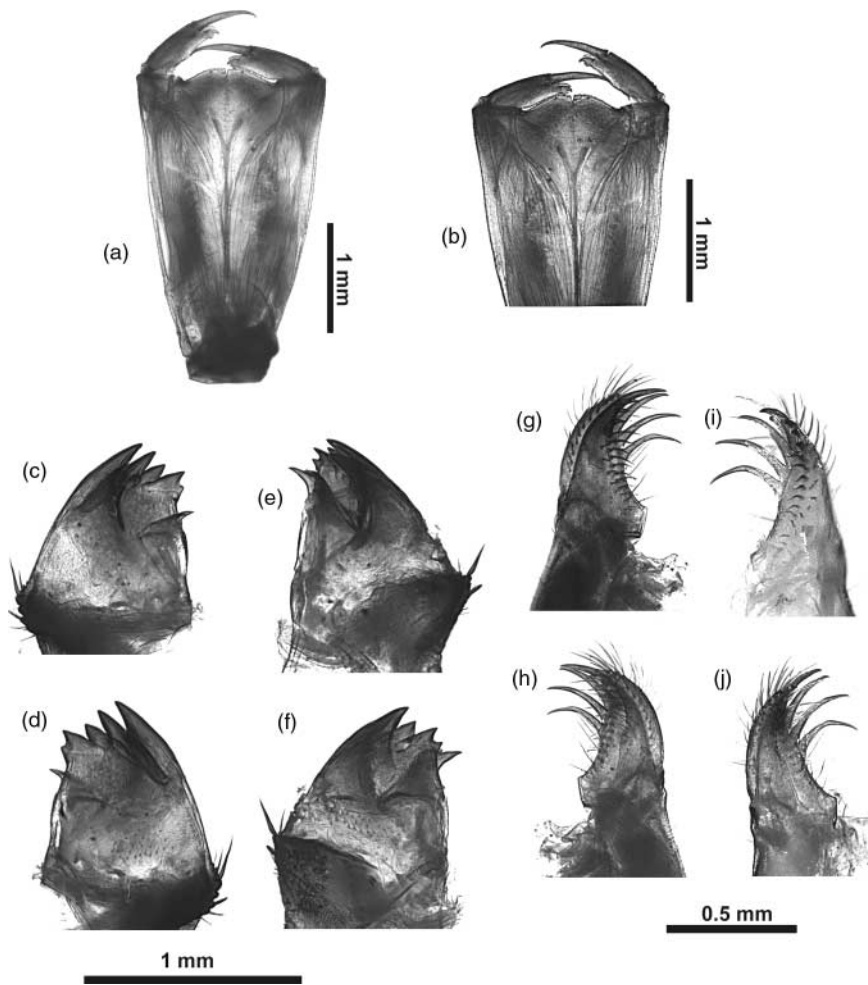


Figure 2. Larval characters of *Pseudolestes mirabilis*: prementum and labial palps, (a) dorsal view and (b) ventral view; left mandible, (c) dorsal view and (d) ventral view; right mandible, (e) dorsal view and (f) ventral view; left maxilla, (g) dorsal view and (h) ventral view; right maxilla, (i) dorsal view and (j) ventral view.

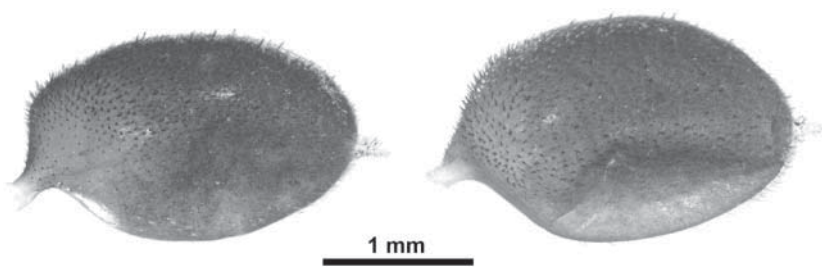


Figure 3. Left lateral caudal gill of F-1 stadium female. Left, outer view; right, inner view.

and finger-like in the earlier instar larva (Figure 3); each lateral gill c.1/5 of total body length excluding antennae with the median one distinctly longer; overall colour rather dark without any pattern.

### *Microhabitat and behaviour*

Larvae were found in both shady and open montane streams with stony substrates. Some even occurred in very small “puddles” covered with dense vegetation formed by discontinuous streams. They usually were found concealed among stones or gravel. Adults can be found in most areas in Hainan; however, as larvae are less conspicuous than adults they are undoubtedly under-sampled. Emergence is from late March to early May. The larvae creep onto the surface of stones just 10–20 cm above the water where they emerge.

### Discussion

Larva of *P. mirabilis* possess paired gill tufts which strongly resemble those of amphipterygids (Corbet, 1999; Novelo-Gutiérrez, 1995; J.A.L. Watson, 1966). It is not clear if the gills are retractable, but it is very probable they are, as described in *Devadatta argyroides* (Orr, 2008). If so, it would seem very probable that the organs are homologous autapomorphies. Elsewhere in the Odonata abdominal gills occur only in larvae of Euphaeidae and Polythoridae (Corbet, 1999; Sisby, 2001). These are simple finger-like ventral-to-lateral projections along much of the abdomen (not S10) and probably evolved independently. They are quite unrelated to the gill tufts of *Pseudolestes*. If closer examination of these should prove them to be essentially the same as the structures known from Amphipterygidae, it would be strong evidence for a shared ancestry. Although the adult characters of *P. mirabilis* are quite different from those of known amphipterygids, the species is so aberrant and has proved so difficult to place that its adult characters may simply be the result of rapid evolution and adaptation associated with its extraordinary agonistic displays (Reels, 2008). In any case, it has proven very difficult to place this species by analysis of adult characters, as evidenced by the variety of suggestions as to its relationships (Lestinae [Tillyard & Fraser 1938–1940]; Pseudolestidae [Fraser, 1957; Davies & Tobin, 1984; van Tol, 2006]; and Megapodagrionidae [Kalkman et al., 2010]). However the presence of gill tufts convincingly separates it from the Megapodagrionidae. Also, in view of the new larval characters, the phylogenetic position of *P. mirabilis* close to Amphipterygidae, recovered in one cladogram based on traditional characters by Rehn (2003), seems the most convincing. Further studies, especially comprehensive molecular analysis, may recover a clear relationship between Pseudolestidae and Amphipterygidae. Presently, we believe *P. mirabilis* should remain in its own family, Pseudolestidae.

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